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Trends and Mapping of Research on Artificial Intelligence-Based Antenna Optimisation: A Bibliometric Analysis

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ABSTRACT

Objective: *This study aims to map the global research landscape on artificial intelligence (AI)-based antenna optimisation using a bibliometric approach. The objective is to identify publication trends, key contributors, collaborative networks, and emerging themes that define the development of this research domain.* ***Method:*** *The analysis was based on 4,814 documents retrieved from the Scopus database for the period 2010–2025. Data preprocessing included deduplication and keyword harmonisation. Bibliometric analysis was conducted using performance metrics (publication trends, influential authors, journals, countries) and science mapping (co-authorship, co-occurrence, co-citation) with VOSviewer and Bibliometrix.* ***Results:*** *Findings reveal three distinct publication phases: initial stagnation (2010–2016), growth (2017–2019), and exponential expansion (2020–2024), with a peak in 2023. China dominates global research output, followed by the United States and India. IEEE journals, particularly IEEE Access and IEEE Transactions on Antennas and Propagation, serve as the primary publication platforms. Co-authorship analysis indicates a highly centralised collaboration network with hubs like Zhang and Wang. At the same time, thematic mapping shows a strong focus on machine learning, deep learning, 5G/6G technologies, and adaptive antenna design.* ***Novelty:*** *This paper provides a systematic, data-driven overview of the intellectual structure and thematic evolution of AI-based antenna optimisation research. It identifies gaps such as limited experimental validation, standardisation issues, and the need for AI-driven inverse design methods for next-generation communication systems.*

INTRODUCTION

Antennas are at the heart of modern wireless systems from micro-scale IoT to macro cellular networks. The demands of 5G, which operates in the millimetre wave range, massive MIMO, and the move towards 6G are forcing antenna designs to become increasingly complex: more compact, multi-band, efficient, with precise radiation patterns in fragile channels. The challenge is not just designing the geometry but balancing multiple objectives with high computational costs, as each evaluation requires a full EM simulation. Classical literature and recent surveys highlight the escalating demands and their impact on antenna design (Rappaport et al., 2013; Andrews et al., 2014; Larsson et al., 2014; Heath et al., 2016; Letaief et al., 2019; Alsharif et al., 2020; Saad et al., 2020; Abbas & Ali, 2021).

On the method side, the antenna community has long utilised two families of techniques: deterministic (gradient-based) optimisation and stochastic evolutionary optimisation. Genetic algorithm (GA), particle swarm optimisation (PSO), and